2.6 CCLME – Salmon – Central and Northern Region

Data and models for freshwater and estuarine ecosystems (salmon)

Nate Mantua, Santa Cruz

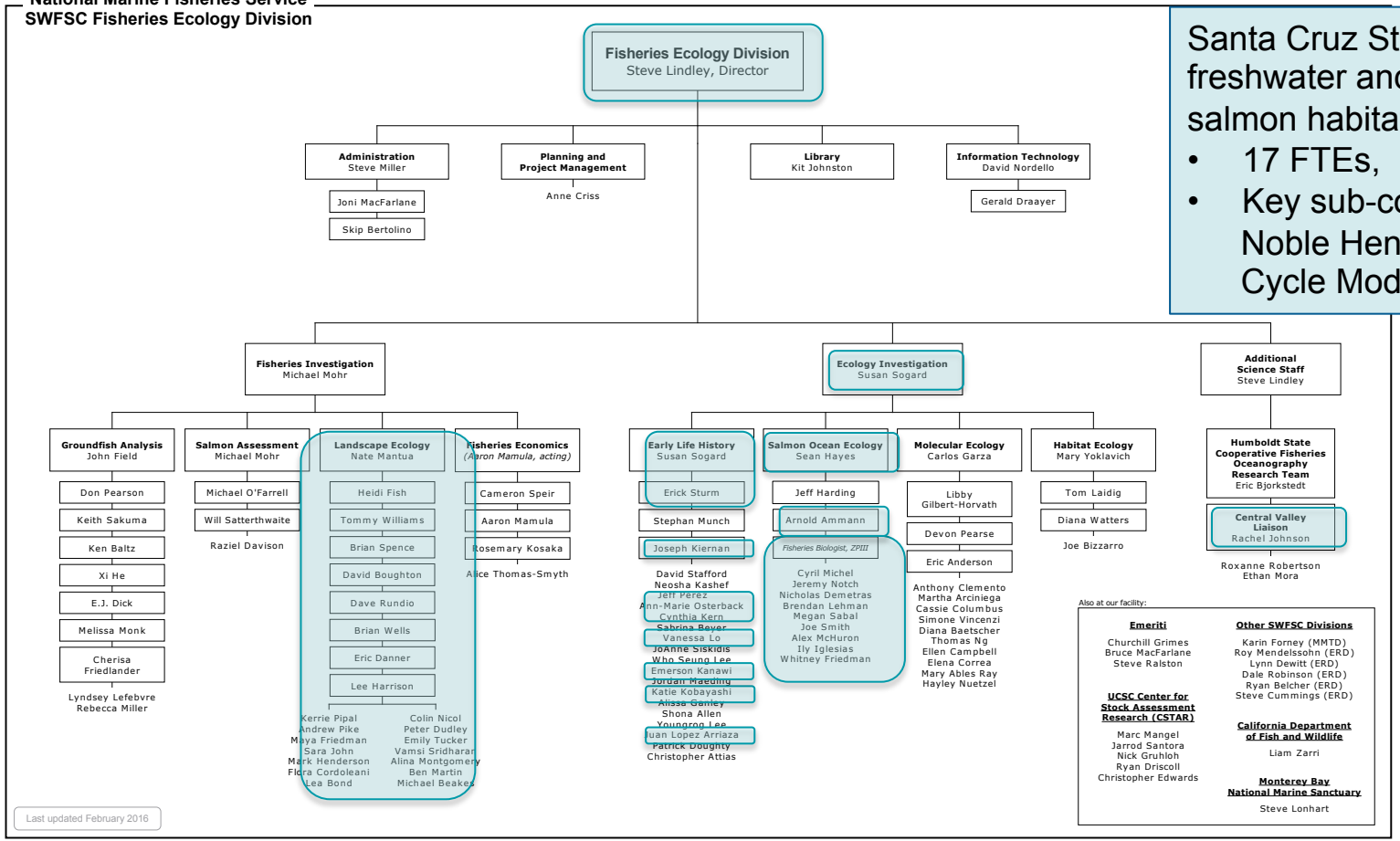
TOR Questions addressed:

4. What is the **status of oceanographic, habitat, climate and ecological data** required to fulfill ecosystem-related science needs? Has the Center developed strategies to obtain and manage such data?

5. Is the Center appropriately **analyzing and modeling ecosystem-level processes**? Are cumulative and integrative ecosystem-level analyses being conducted? If not, is there a plan in place to initiate or contribute to the science needed to address cumulative impacts?

6. Is the Center's oceanographic, habitat, climate and ecological advice sufficiently **included into living marine resource management advice**? Are there suitable mechanisms to determine when such inclusion is warranted?

National Marine Fisheries Service
SWFSC Fisheries Ecology Division



Santa Cruz Staff involved in freshwater and estuary salmon habitat studies

- 17 FTEs, 30 UCSC
- Key sub-contract with Noble Hendrix for Life Cycle Modeling

Funding

- Funding for salmon research has grown
  - Almost entirely through external sources, including Bureau of Reclamation, DWR, NASA, and CDFW

Our research uses the salmon life cycle as the conceptual framework for identifying data and information needs

Research and Modeling:

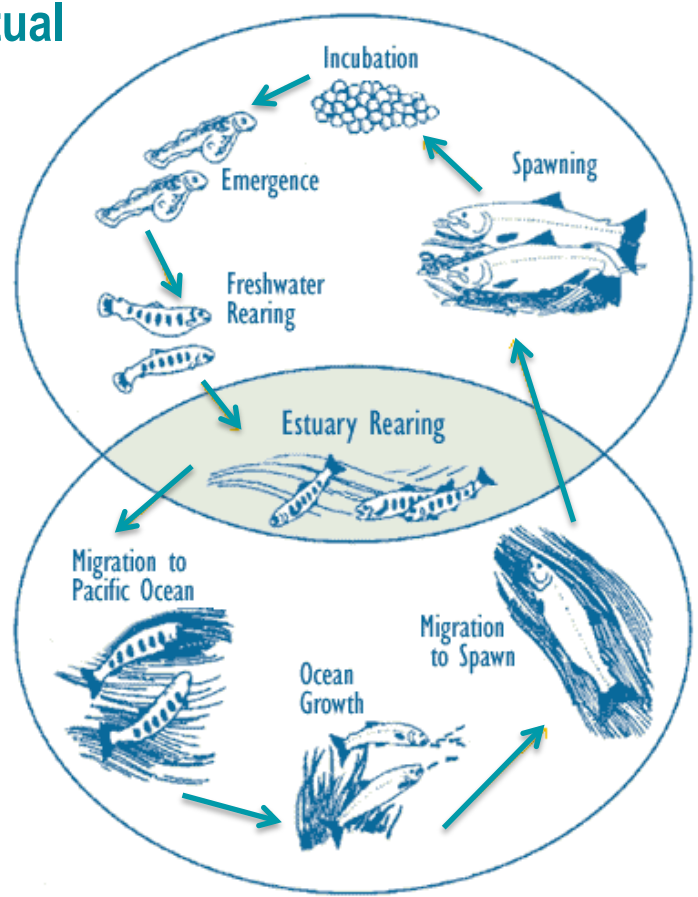
- **Process-Based**: flow and temperature, floodplain/river interactions, particle tracking model for the delta, dynamic energy budget (costs of migration, growth efficiency, egg-to-fry development)
- **Empirical/statistical**: water temperature and egg to fry survival rates; environmental drivers for migration, pre-spawn mortality
- **Life cycle models:** "virtual labs" for evaluating restoration and management actions, climate change scenarios, data and information needs

Field Studies

- **Life cycle monitoring**: tagging and tracking for predation, migration, habitat use, key predators, predation hot spots, and population dynamics studies
- **Remote sensing** for habitat mapping, habitat responses to disturbance

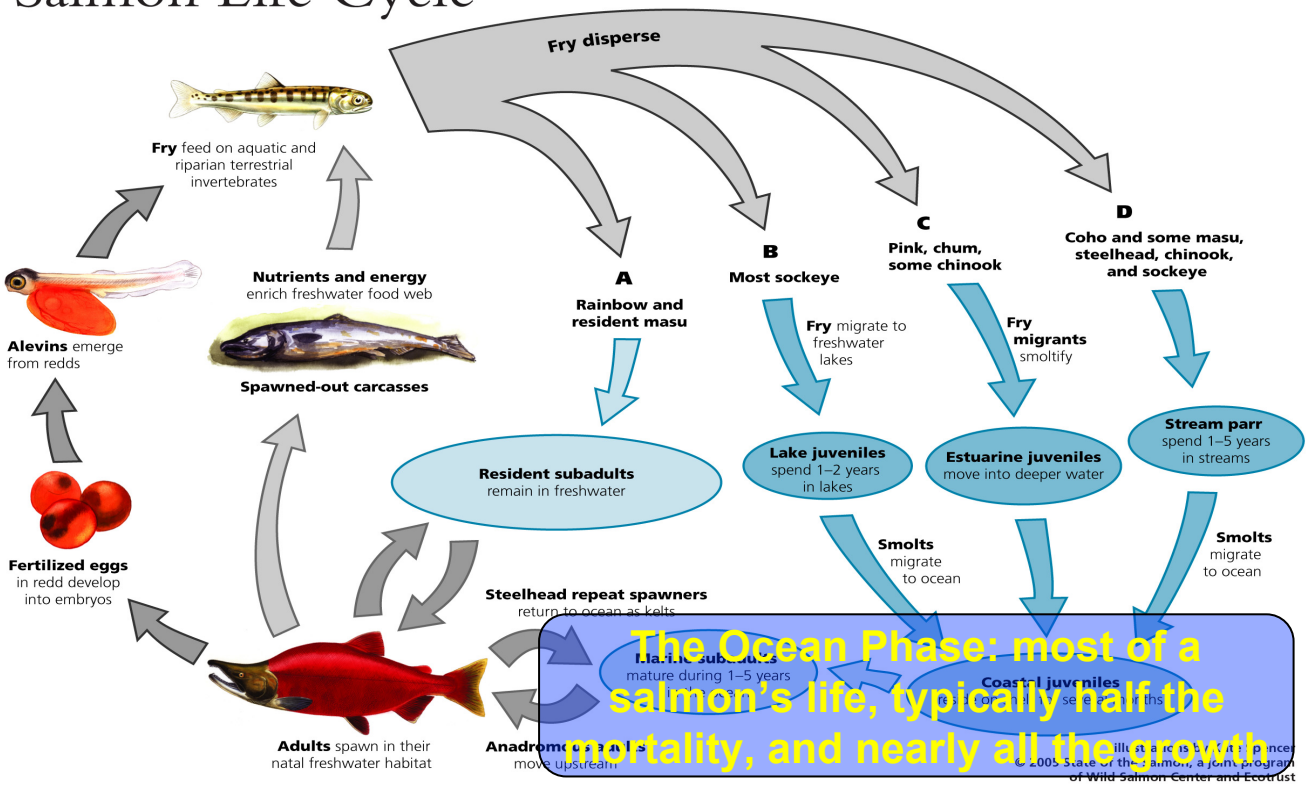
Laboratory/Hatchery studies

- Basic **physiology**
- **Experimental hatchery** release practices for conservation goals

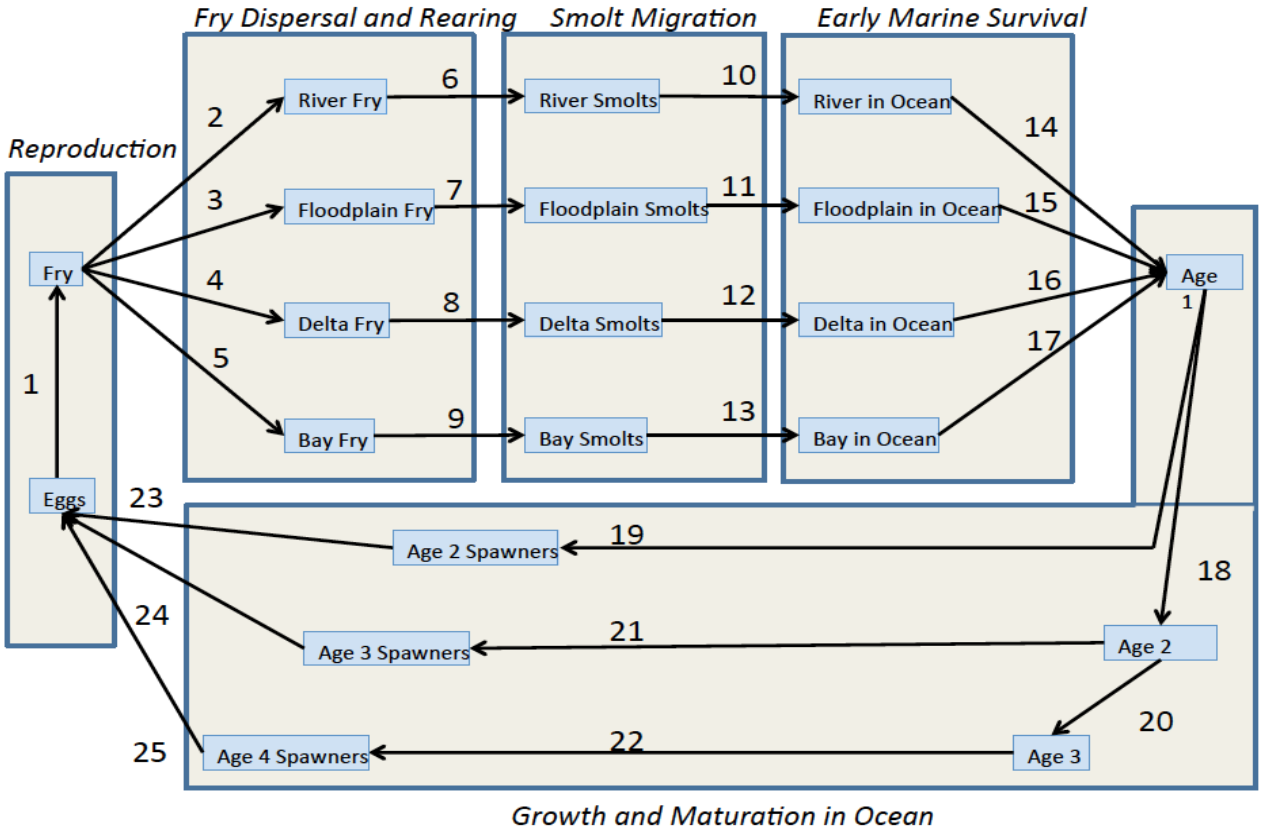


Life history diversity

- Critical element in the success of the genus, each species, individual population groups (ESUs/DPSs), and individual breeding populations



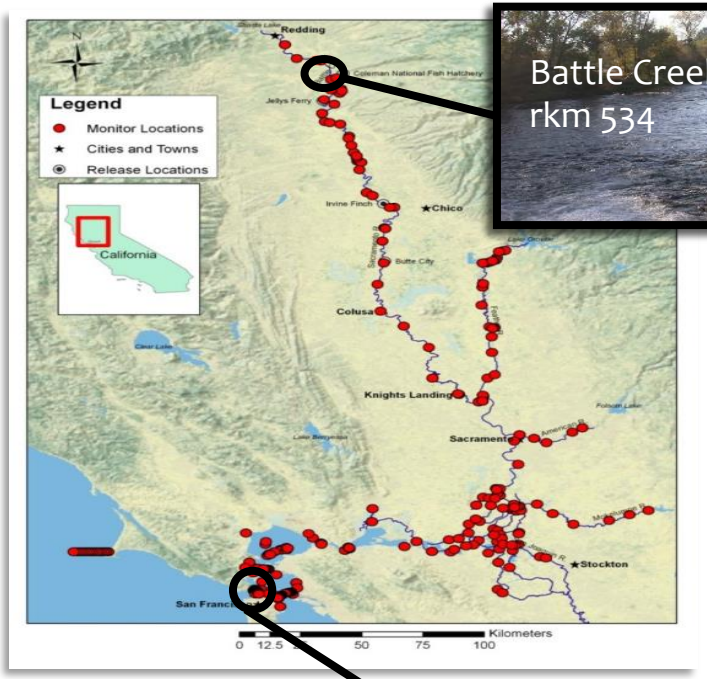
The Central Valley Chinook Life Cycle Model

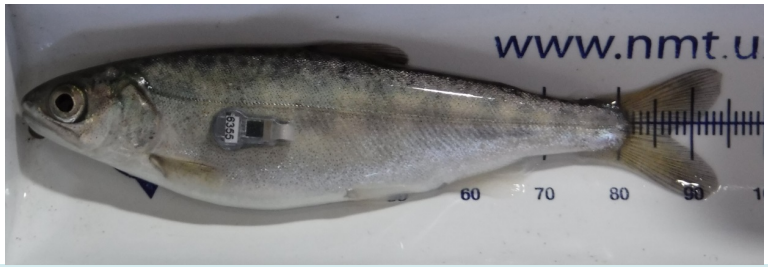


Need more data and process-level understanding to inform LCMs and related decision-support tools

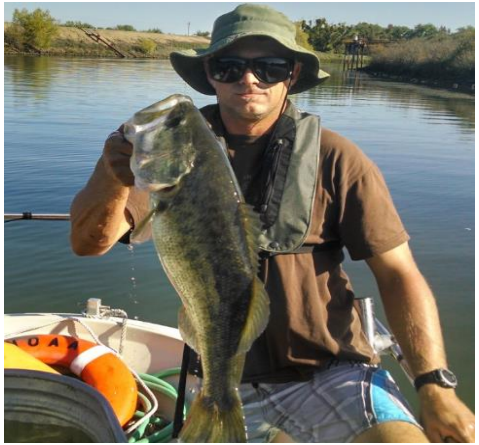
Empirical studies

- Juvenile outmigration survival
- Predation studies
  - Impact of water diversion
  - Habitat-Density interactions





Mortality Causes?



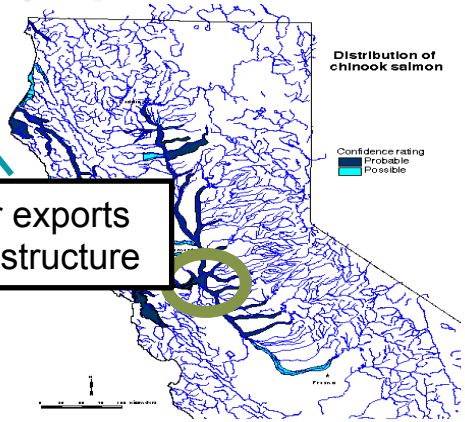
ESA-listed salmon and steelhead

?

Non-native predators

+

Water exports & infrastructure



Delta Predation Studies

- ***Objective 1*** - Determine representative **densities and local spatial distributions of predator fish**
- ***Objective 2*** - Quantify the magnitude of predation through **genetic analysis of predator stomach contents**
- ***Objective 3*** - Conduct a controlled large-scale **experiment that manipulates the density of predators**
- ***Objective 4*** - Determine how predation on salmon smolts may be influenced by **physical habitat, water chemistry, and other environmental features**

Drought highlights ongoing issues

NEWS

Lingering drought heightens worries of extinction for salmon

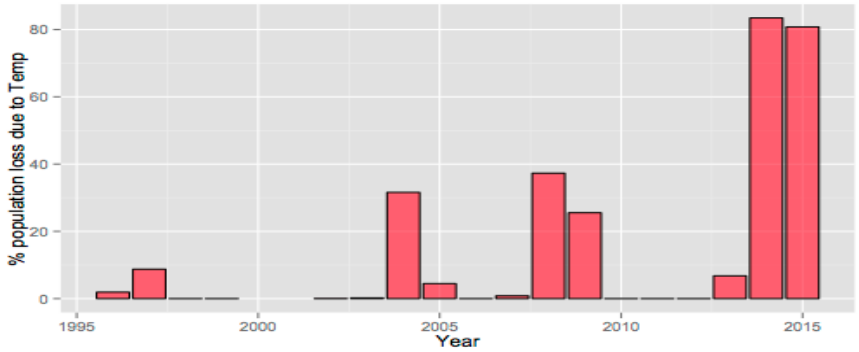
By ELLEN KNICKMEYER Associated Press | 4:40 p.m. Oct. 28, 2015

U.S.

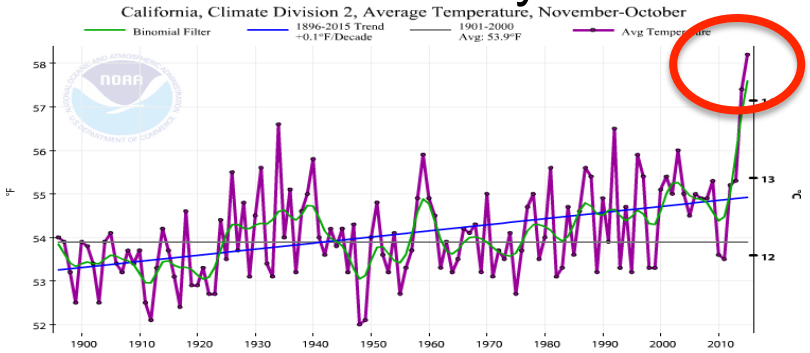
California Dam Lets Water Shared by Farms Flow to Salmon

By THE ASSOCIATED PRESS AUG. 22, 2015

River temperature driven salmon egg mortality



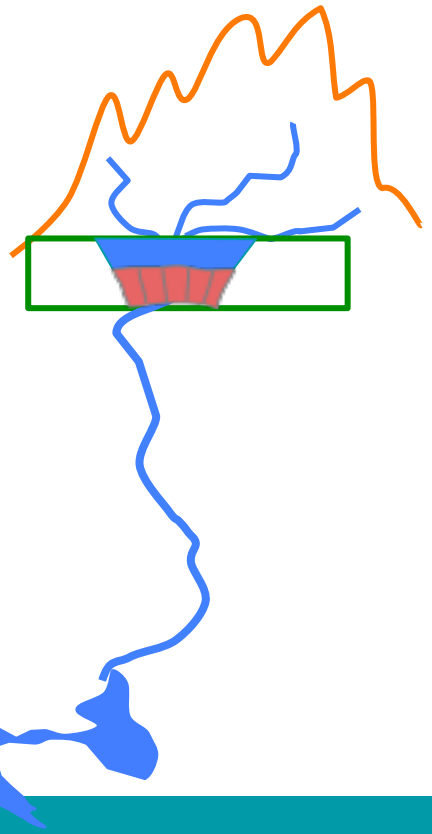
Hottest year on record in the Central Valley



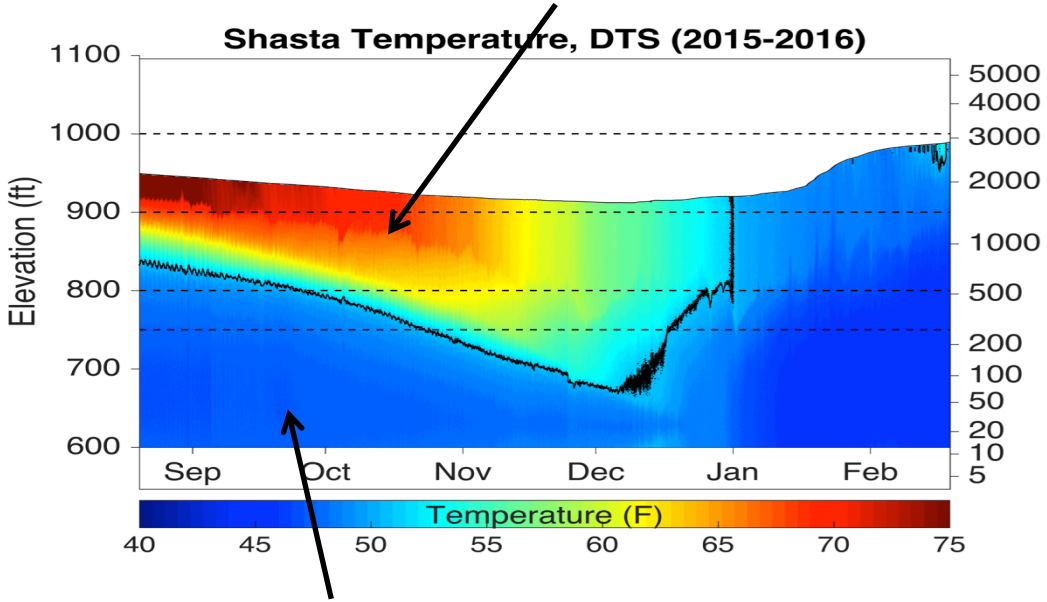
NOAA FISHERIES

The Reservoir: The main control point

Reservoir



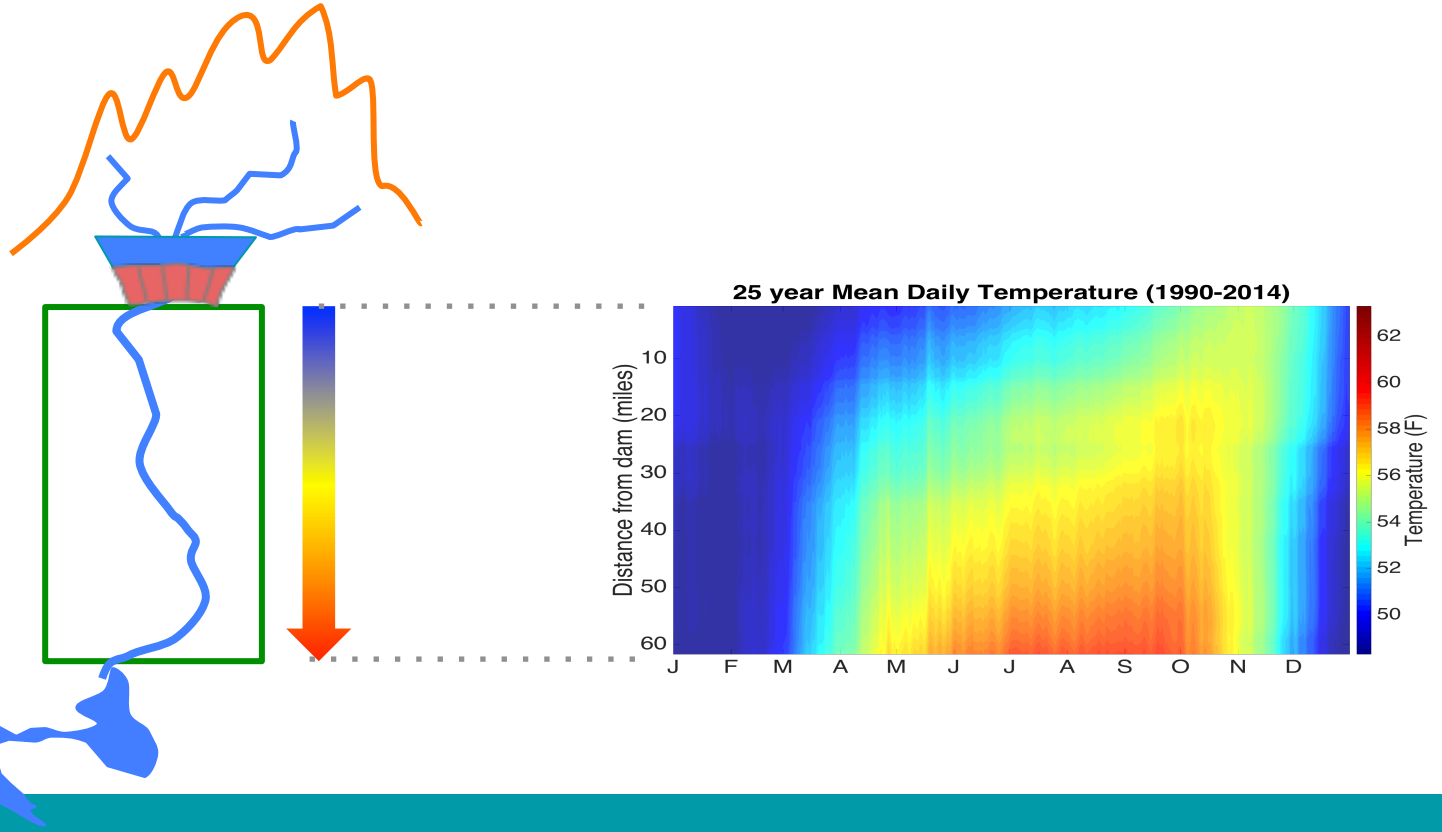
Too warm for salmon downstream



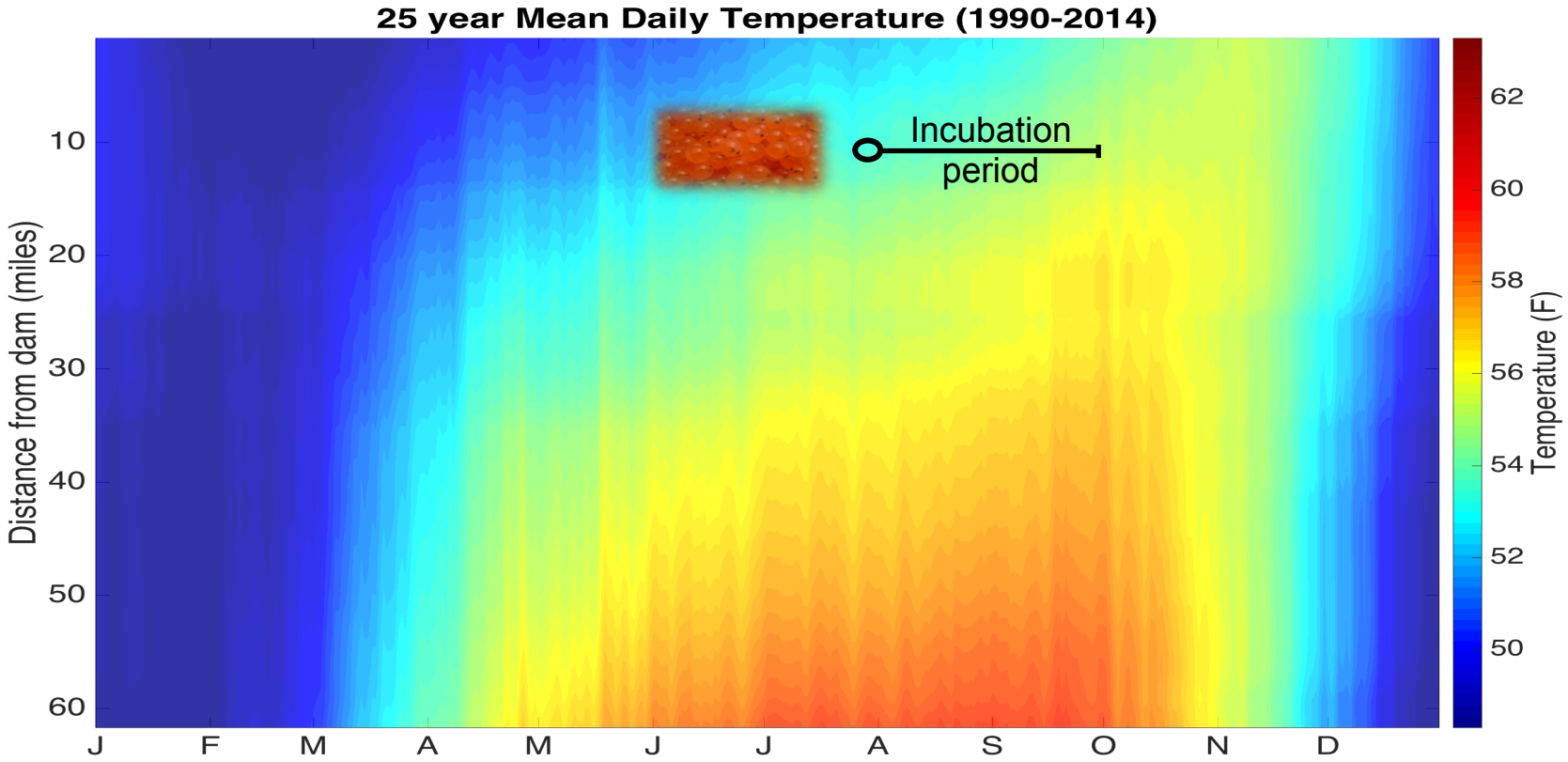
Cold enough for salmon downstream

The River: Where management impacts fish

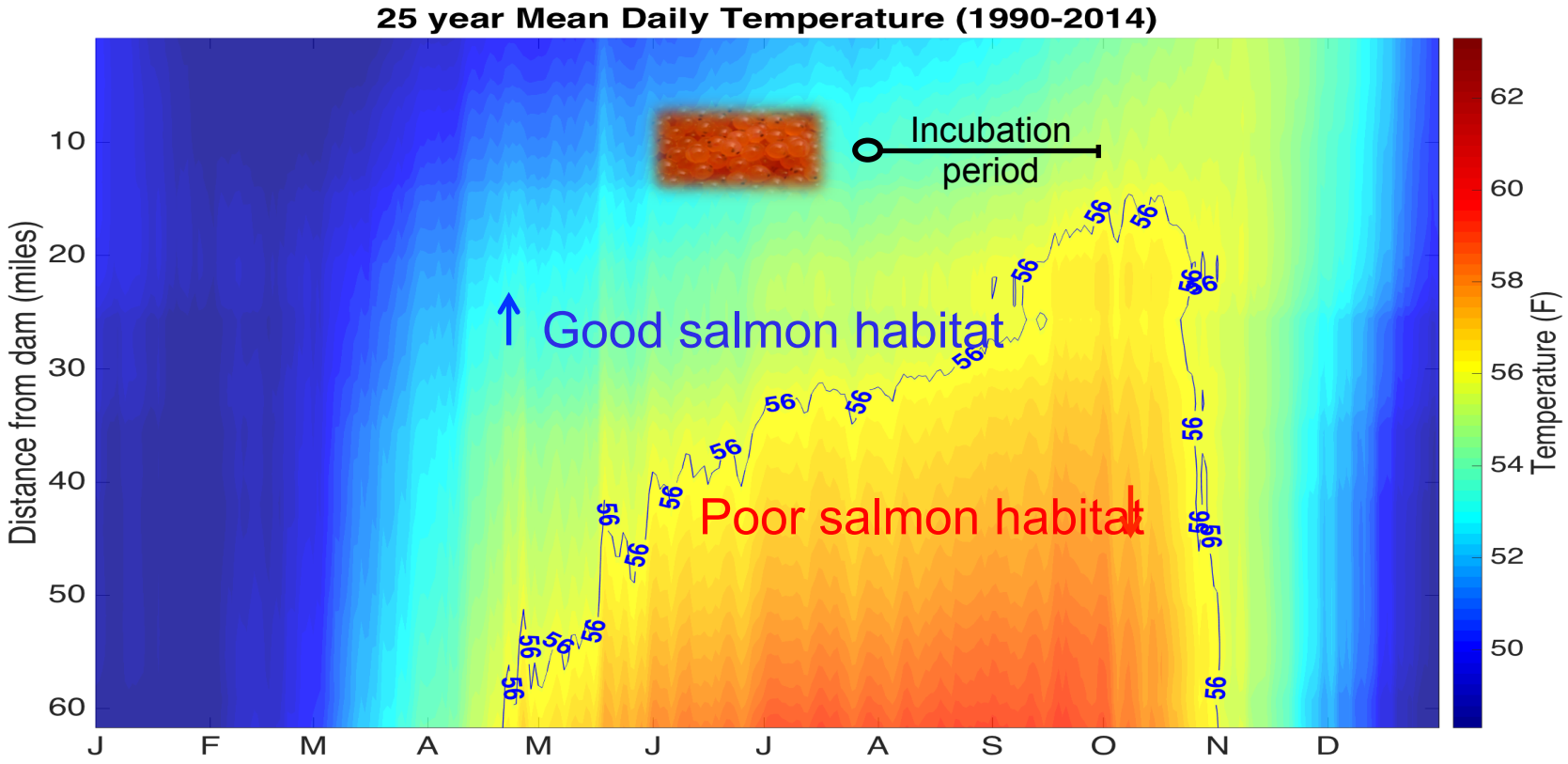
River



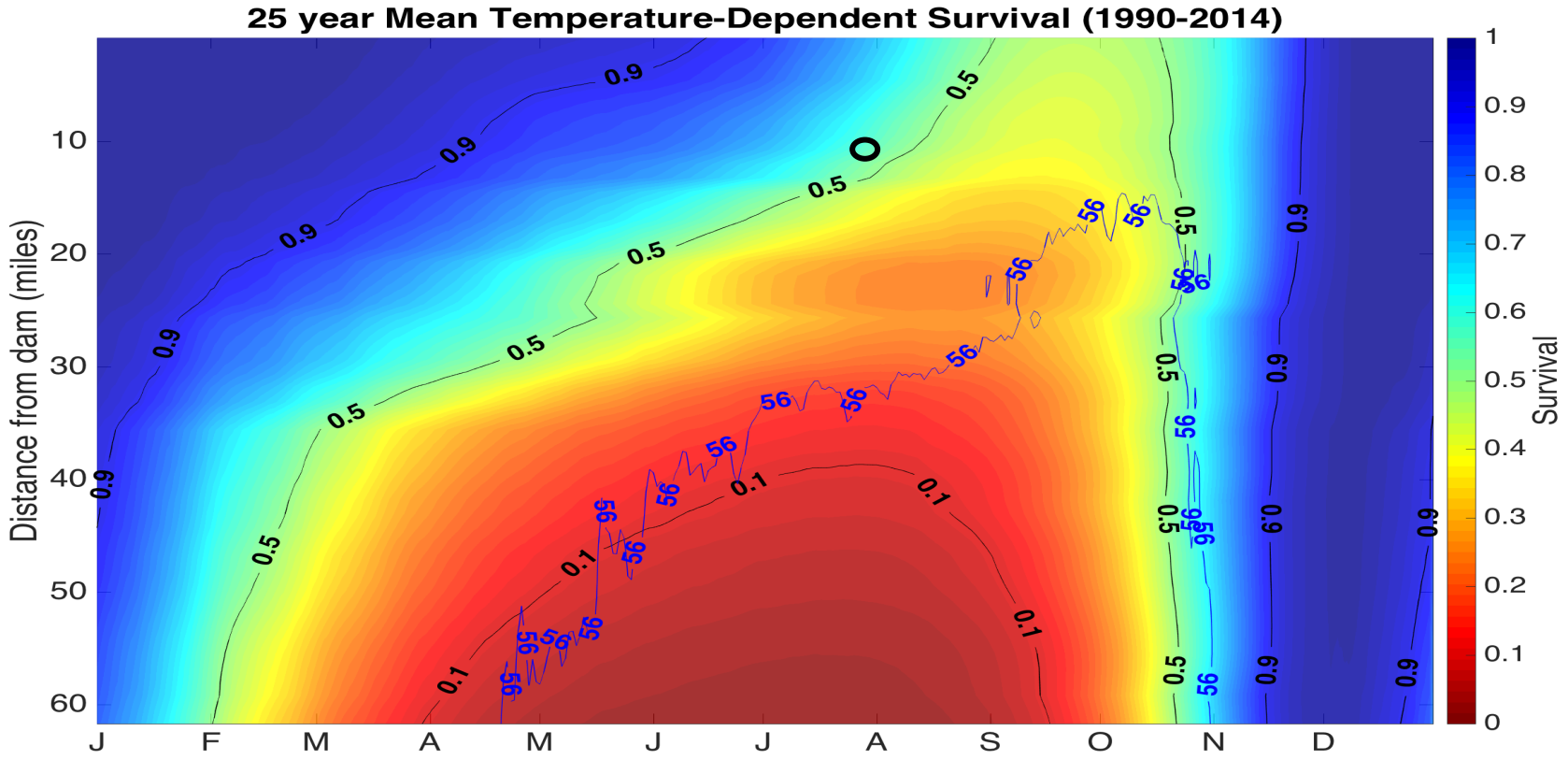
River Temperatures



River Temperatures



Salmon survival as a function of temperature



What I haven't shown you

- Life cycle monitoring in small coastal streams
- Role of lagoon habitats for steelhead rearing
- Carmel River dam removal and population dynamics studies
- Central Coast coho salmon hatchery rearing and release experiment
- Habitat remote sensing
- Linked IBM/hydraulic models to inform habitat restoration actions
- Habitat assessments for reintroductions above high dams
- Particle tracking model for Delta
- Linked habitat/IBM models for salmon spawning, incubation, and early rearing
- Stream temperature modeling (RAFT) for decision-support
- Salmon swim-chamber physiology experiments1

Strengths

- outstanding personnel with diverse and complimentary expertise
- integration of fieldwork, lab, and modeling studies
- strong commitment to publishing in peer-reviewed literature and sharing data
- active participation in scientific advisory panels and committees
- excellent relationships with NMFS Regional Office
    - Close coordination between our people developing decision-support tools and the resource managers looking for scientific advice

Challenges

- Project stability challenged by soft $ and 80% contractor load
    - lots of turnover in contractor staff (Santa Cruz: high cost of living, limited opportunities for partners, desire for permanent positions)
- California's multi-year drought, extreme ocean conditions in 2014-2015
- Refocus metric of success from 'smolts out' to 'adults back'
- Research in politically charged arenas
- predator population and habitat dynamics largely unstudied

Strategies

- Work with interagency partners (USFWS, US Bureau of Reclamation, CA Department of Water Resources, CA Department of Fish and Game) to establish more stable and secure program funding in multiyear (5 or 10 year) agreements

- Maintain transparency and credibility: continue to publish research results in peer-reviewed literature, engage with decision-makers, share data and smolt tracking infrastructure (e.g. hydrophone network for acoustic tags)

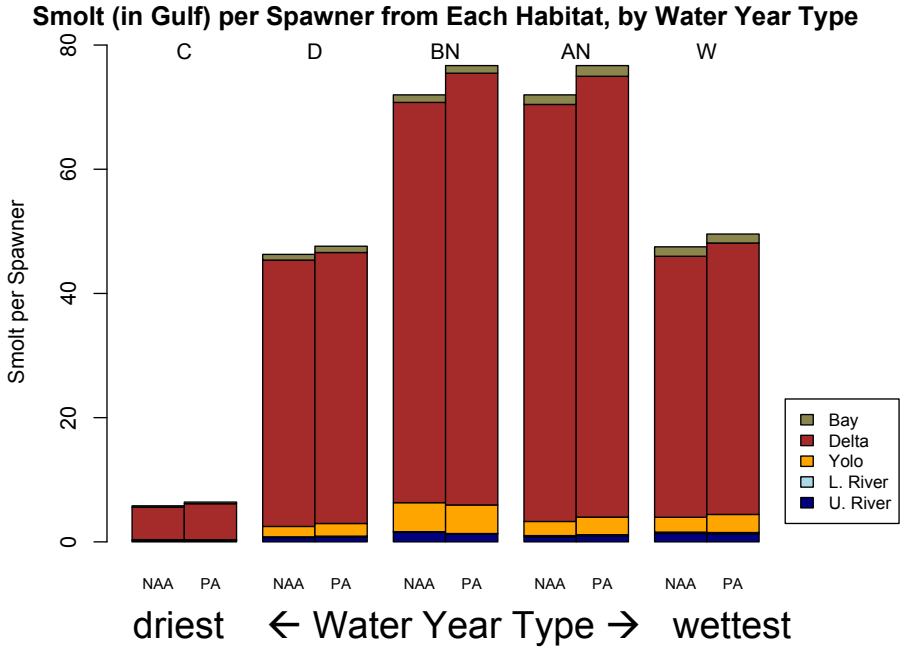
- Continue to use life cycle model as framework for identifying knowledge gaps, prioritizing field work and new hires

Winter run Chinook salmon LCM preliminary results

NAA = “no action alternative” w/current water project operation rules with RPAs

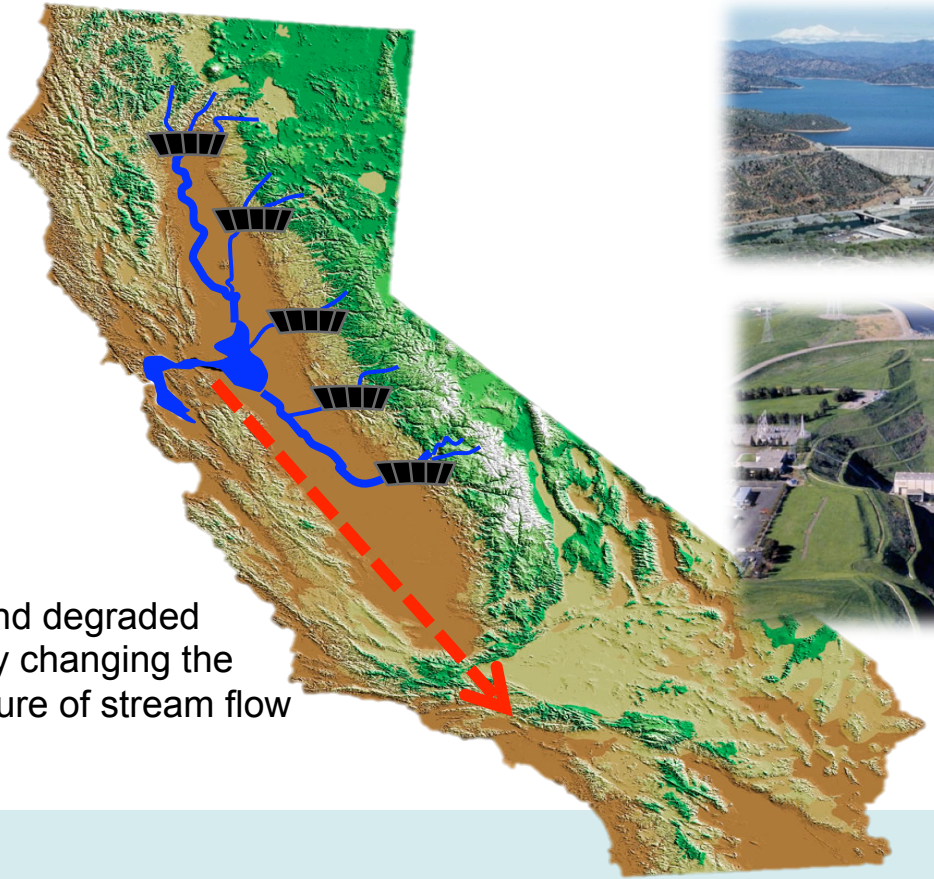
PA = “preferred alternative” (WaterFix, i.e. twin tunnels under the Delta)

- Most rearing occurs in the delta
- More production in “near-normal” water years; depends on timing and magnitude of the flows
- These results don’t yet properly capture the effect of future Yolo Bypass operations, which should increase production from Yolo floodplain habitat



Water and salmon in California

NOAA
NMFS

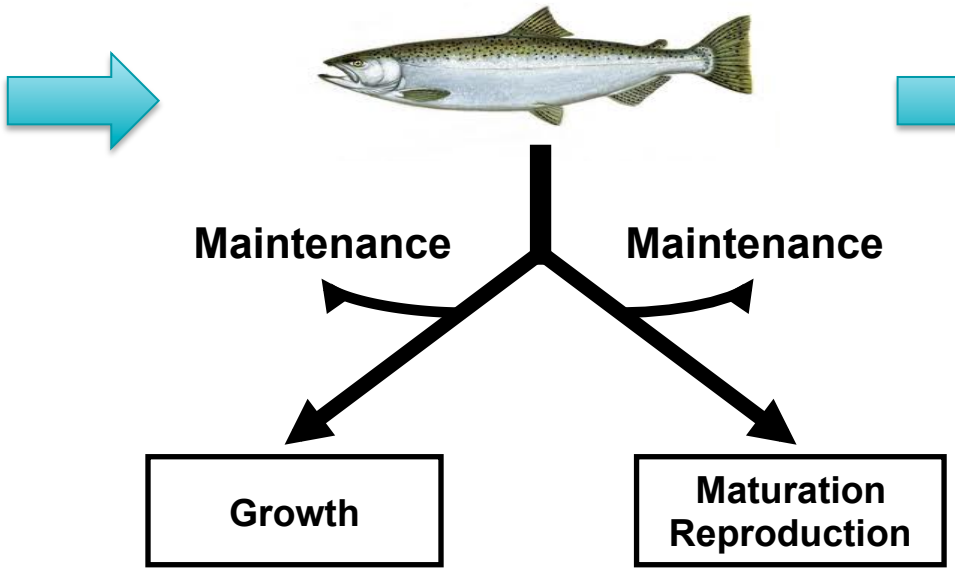


We have massively altered and degraded salmon habitat, fundamentally changing the volume, timing, and temperature of stream flow

Dynamic Energy Budget (DEB) Models

Input

Food
Temperature
Velocity



Output

Growth
Fecundity
Migration costs
Embryonic dev.
Age at maturity


15006
REWARD IF RETURNED:
Amicul Ammann at
NOAA FISHERIES
110 SHAFFER ROAD
SANTA CRUZ, CA 95060
(831) 420-3948
(831) 331-9947

What about PIT tags?

- Two year feasibility study (2015-16)
- NOAA (SWFSC and NWFSC), USBR and CA DFW
- Deploy existing small-channel antennas a
- Engineer and deploy prototype large-channel detection arrays at two locations
- Develop/test boat -trawl antennas in the estuary
- Tag and release juvenile salmonids to estimate detection efficiency
- Identify additional sites

Bass present for 130+ years, why a problem now?

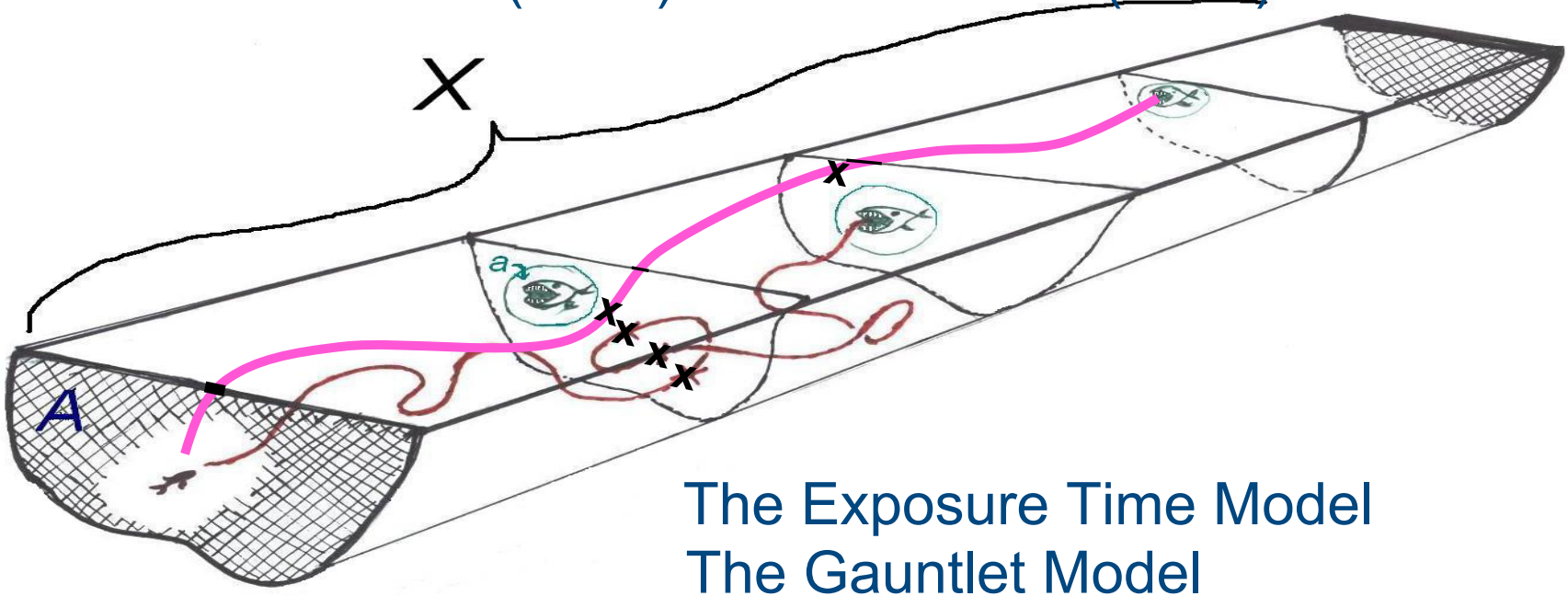
- Constant introductions of Invasive Species
  - Asian Clams
    - *Corbicula fluminea*
    - *Potamocorbula amurensis,*

  - Aquatic Plants
    - *Egeria densa*

    - **Water Hyacinth**

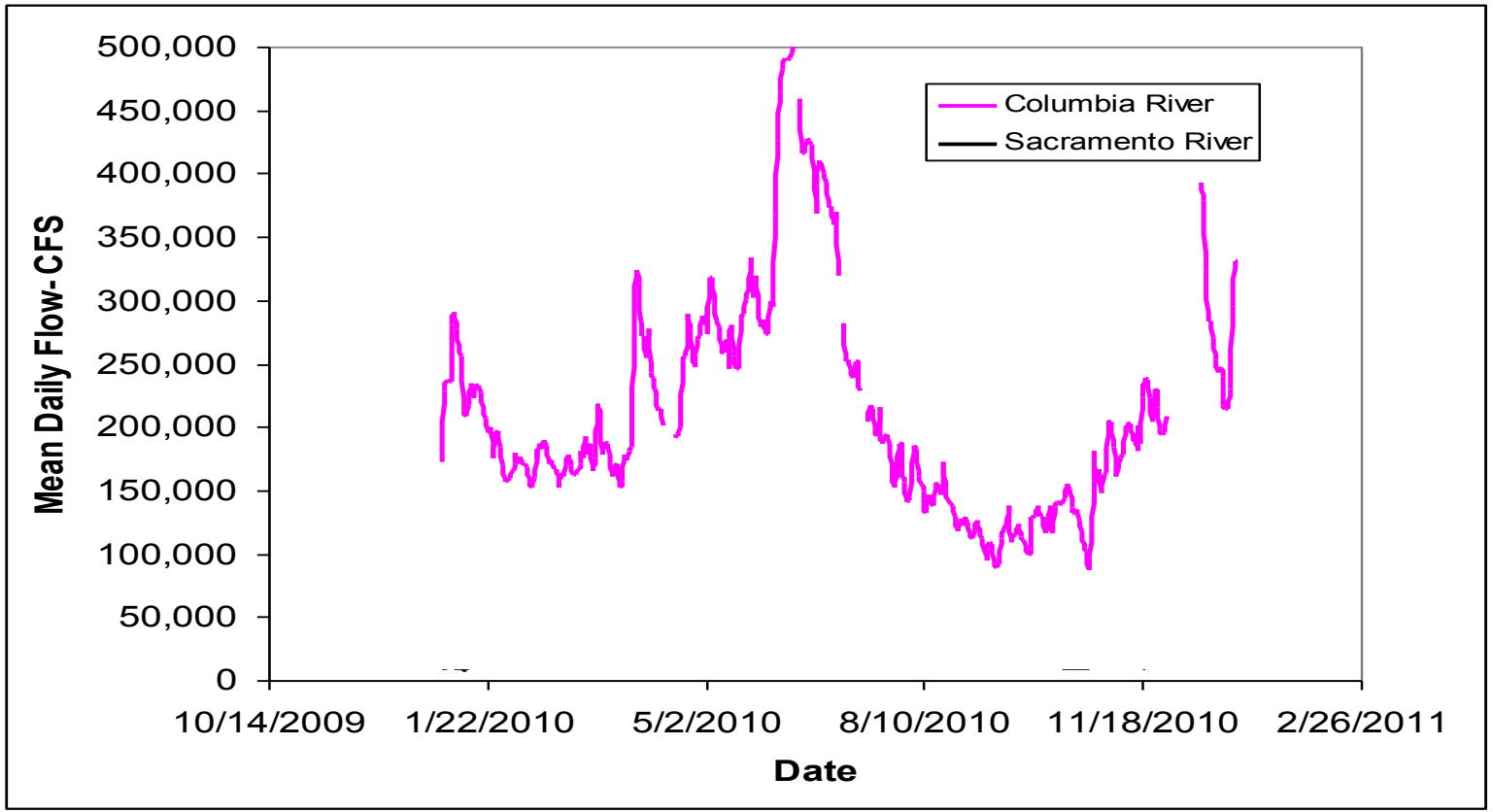
The XT Model Cartoon

Gurarie (2008) Anderson et al. (2005)



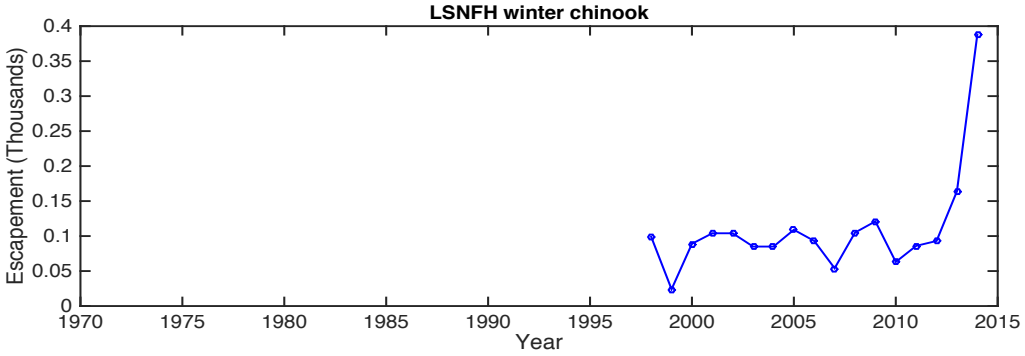
The Exposure Time Model
The Gauntlet Model

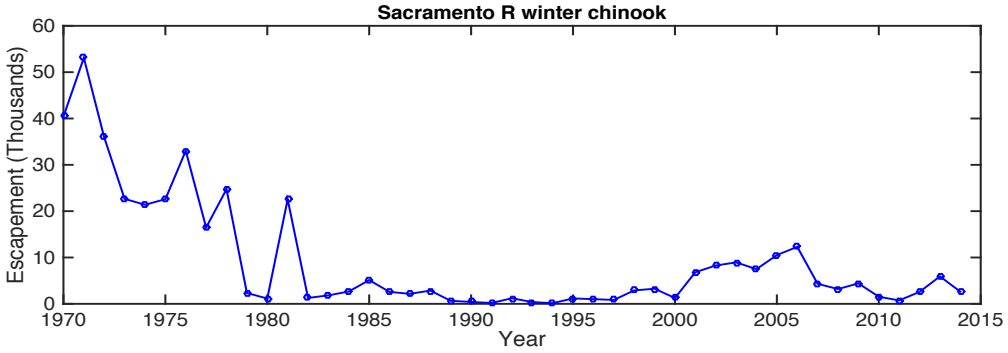
California vs the Pacific Northwest……



SPECIES in the SPOTLIGHT

http://www.nmfs.noaa.gov/stories/2015/09/spotlight_chinook_salmon.html





Report

of the

Technical Review Panel

Review of the Biological Opinion

of the Long-Term Central Valley Project

and State Water Project Operations Criteria and Plan

For

Johnnie Moore

Lead Scientist

California Bay-Delta Authority

December 2005

NMFS Science Center Evaluation of the Peer Reviews of the Long-Term Central Valley Project and State Water Project Operations Section 7 Consultation.

25 May 2006

Steve Lindley (SWFSC, chairman)
Chris Legault (NEFSC)
Phil Mundy (AFSC)
Jeff Murphy (NERO)
Robin Waples (NWFSC)

Independent Review of a Draft Version of the 2009 NMFS OCAP Biological Opinion

January 23, 2009

CALFED Science Review Panel

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University of Washington
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and **Associate Adjunct Professor**
School of Natural Sciences
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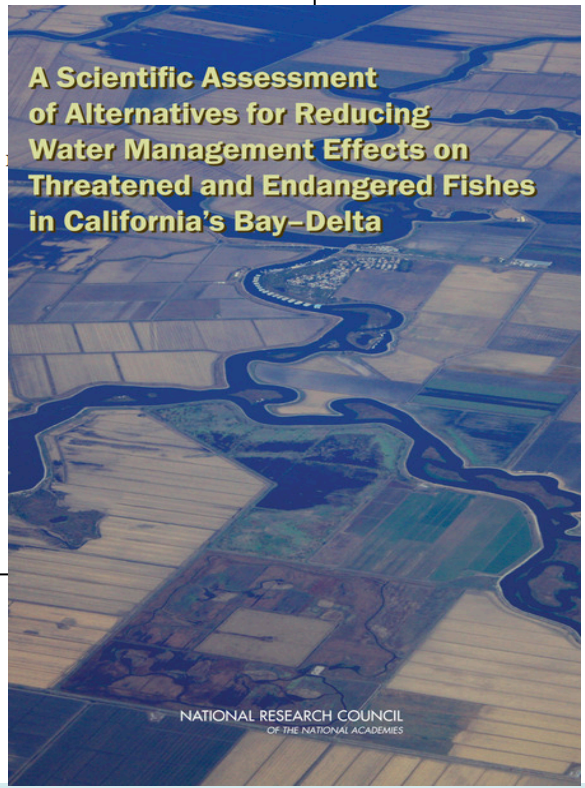
pduffy@climatecentral.org



Salmonid Integrated Life Cycle Models Workshop

Report of the Independent Workshop Panel

Panel members:

Kenneth Rose (Louisiana State University), Chairperson

James Anderson (University of Washington)

Michelle McClure (NOAA, Northwest Fisheries Science Center)

Gregory Ruggerone (Natural Resources Consultants, Inc.)

Workshop Organized by the Delta Science Program

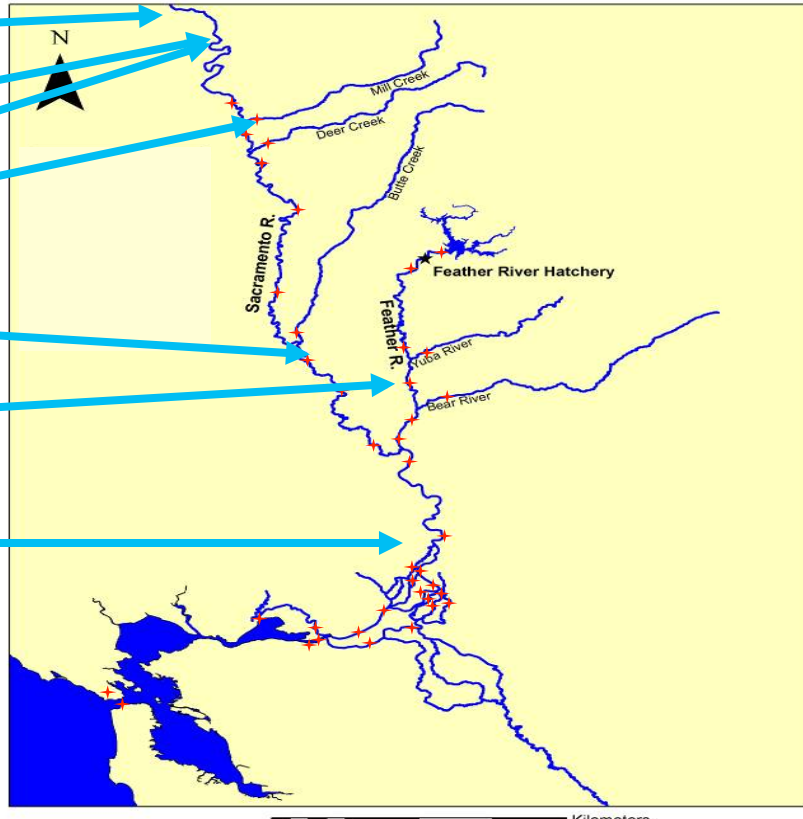
June 14, 2011

1. developed and scaled for the questions to be addressed
2. Resolution clearly stated
3. designed from the ground-up
4. A standard glossary should be prepared and updated periodically
5. documentation should be prepared and tailored to the audience
6. difference between precision and accuracy should be maintained
7. A peer-review panel should be established to provide periodic feedback and advice
8. Development of the new model should proceed as a series of iterative steps from the questions to the formulation of a new model.
9. **A transparent strategy that utilizes available data should be developed for calibration and validation.**
10. Sensitivity and uncertainty analysis integral to the model is not the last step in model analysis.
11. Careful use of linked models is necessary to minimize propagation of unknown biases and uncertainties into final predictions.
12. A parallel effort of data synthesis should be started with the initiation of the modeling effort.
13. Critical aspects of the developed model will be: density-dependence, time-stepping, spatial grid, routing into and through the Delta, and ocean growth and survival.
14. Consideration of life history variation and spatial distribution, in addition to usual focus on population abundance, is needed in order to address the VSP criteria.
15. An important consideration for a NMFS model is that NMFS must have complete ownership of the model
16. Manpower and resources

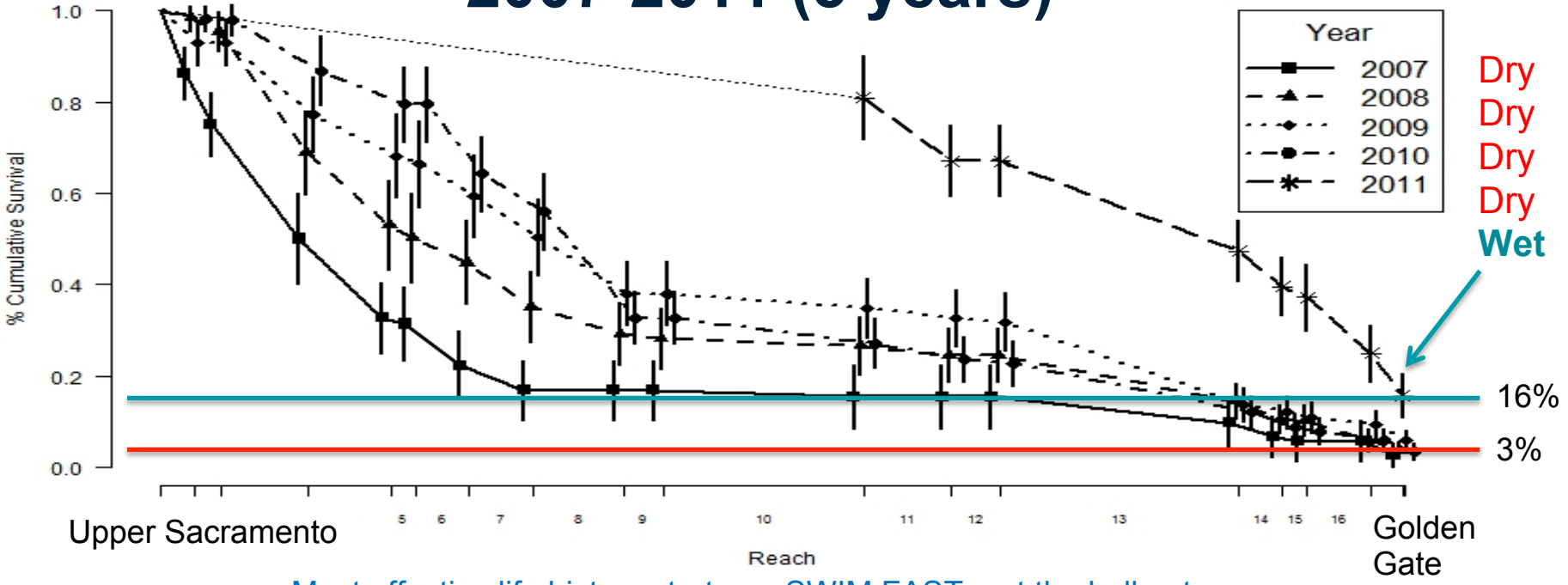
Tagging Schedule 2012-2015

Tagging goals

- Winter run- LSNFS
  - 200-400 Jan
- Fall run- CNFH
  - 150 x 2 early/late Apr
- **Wild** tagging Spring and Fall
  - Mill, Battle, Butte-Sutter
  - 200-400 Nov-May
- Spring run from FRFH
  - 150 x2 Apr- upper/lower river
- Fall and Spring run releases into Delta
  - 100 f/100s x2 (repeat Perry et al 2010)

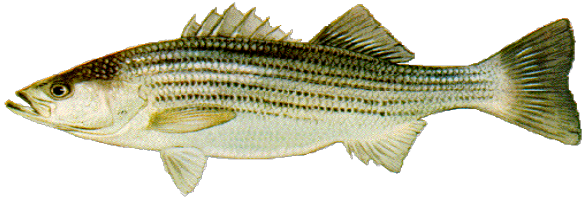


Late Fall Chinook Survival to Golden Gate 2007-2011 (5 years)



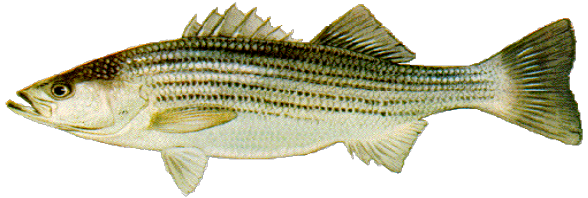
- Most effective life history strategy- SWIM FAST, get the hell out…
- 84-97% mortality occurs in 2-3 weeks post hatchery release
- More water appears to = More fish…

Effect of habitat on predation rate?



Diet in lower river = 80% crayfish, 0 salmon

- Habitat alterations matter!



+

Diet at Dam = 80% salmon

The Predator Issue….. Just how bad is it?

Loboschefsky, E., Benigno, G., Sommer, T., Rose, K., Ginn, T., Massoudieh, A., and Loge, F. 2012. Individual-level and Population-level Historical Prey Demand of San Francisco Estuary Striped Bass Using a Bioenergetics Model. San Francisco Estuary and Watershed Science **10**(1).

- Sacramento Bay/Delta populations of striped bass consume….

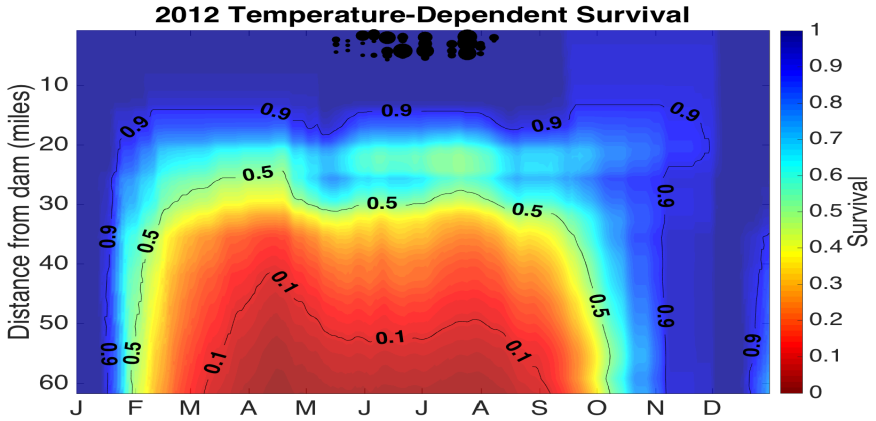
  ~25,000,000 kg of fish per year

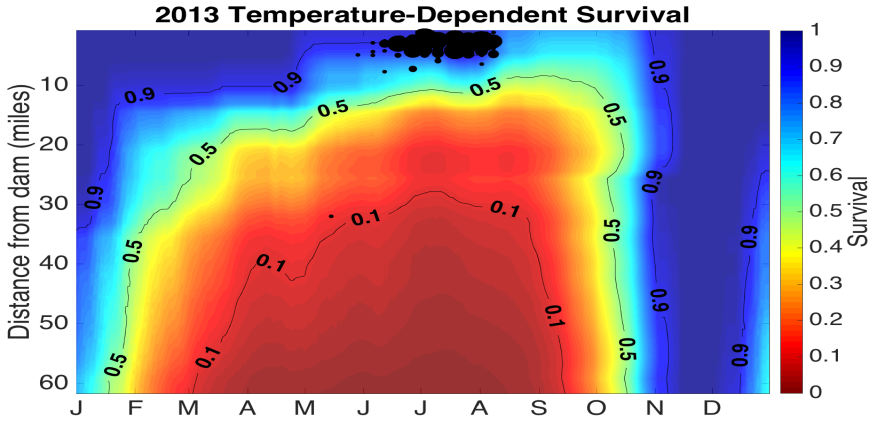
All Central Valley juvenile salmon

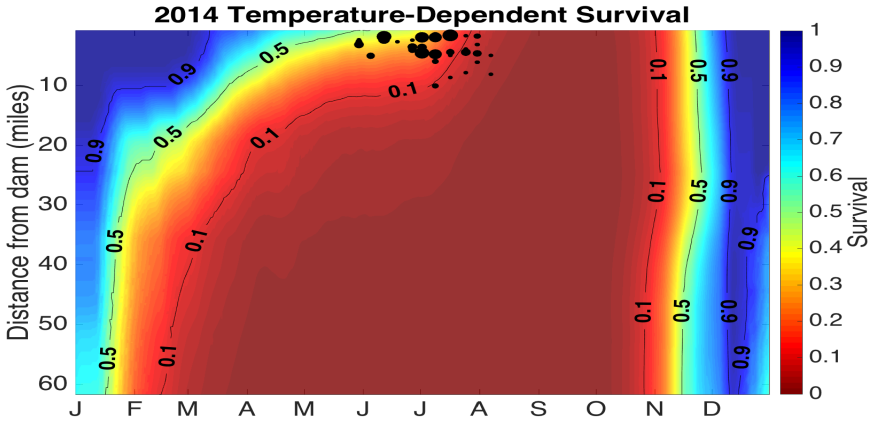
~240,000 kg

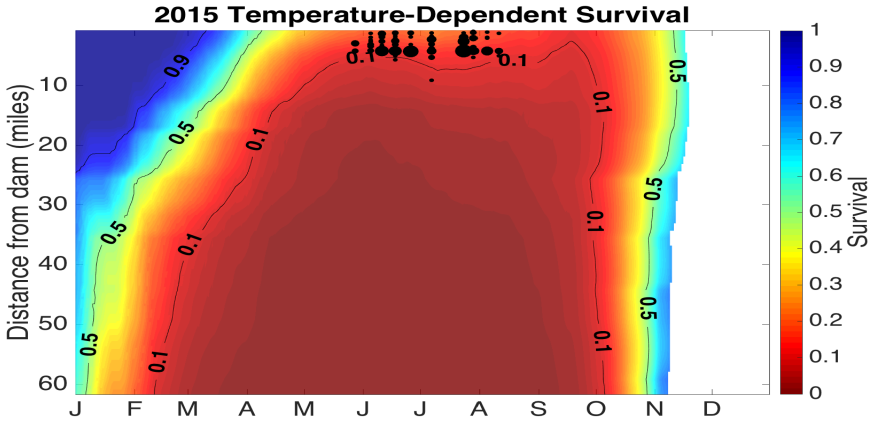
~1% of bass diet?

As we head into a drought…









Research to Applications

From Ryan Wulff, Branch Chief, Delta Policy and Restoration, NOAA's West Coast Regional Office, Sacramento, CA

Eric Danner's work has been vital to current real-time operational decisions related to water management in the Central Valley. Drought conditions over the last four years have highlighted the uncertainties in Reclamation's Sacramento River Water Quality Model and its inability to meet the regulatory requirements outlined in the NMFS Biological Opinion. Given the loss of two out of three cohorts of endangered winter-run Chinook salmon, accurate temperature modeling is vital for this water year. Given the poor performance and uncertainties associated with Reclamation's model and the extreme importance to manage for higher juvenile winter-run survival during the temperature management season this year, NMFS has relied heavily on Eric's work to plan for operations throughout the rest of the year.